

1 CLAIMS

What is claimed is:

- 5 1. An apparatus for driving lasers, the apparatus comprising:
- a laser current controller for providing a modulation signal and a bias signal;
 - 10 a plurality of high-speed current drivers that accept the modulation signal and the bias signal and produce a plurality of laser drive signals; and
 - a disable input that selectively disables power to at least one high-speed current driver when the high-speed current driver is not in use.
- 15 2. The apparatus of claim 1 wherein the apparatus is integrated on an integrated circuit.
3. The apparatus of claim 2 further comprising an integrated
- 20 array of lasers coupled to the plurality of high-speed current drivers for receiving the plurality of laser drive signals.
4. The apparatus of claim 1 wherein the laser current controller comprises:
- 25 an automatic power control (APC) input that accepts a digital APC signal; and
- circuitry that adjusts the modulation signal and bias signal to the high-speed current drivers.
- 30 5. The apparatus of claim 1 further comprising
- a high-speed current driver that drives a feedback laser; and
 - a feedback circuit that accepts a signal from the feedback laser and generates a modulation feedback signal and a bias feedback signal and provides them to the laser current controller.

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6. The apparatus of claim 5 wherein the feedback circuit comprises:

5 a peak to peak detector that generates the modulation feedback signal; and

an average value detector that generates the bias feedback signal.

7. The apparatus of claim 1 further comprising at least one
10 high-speed current driver, which does not have a disable input.

8. The apparatus of claim 6 further comprising a photo
15 detector that detects laser light produced by a laser driven by one of the high-speed current drivers of the integrated driver and provides it to the peak detector and the average value detector.

9. The apparatus of claim 8 wherein the laser, which
20 provides light to the photodetector, is a control laser, which is modulated by a signal of substantially lower frequency than a maximum frequency of the data lasers.

10. The apparatus of claim 8 wherein the modulating frequency
25 is approximately 100 MHZ.

11. The apparatus of claim 9 wherein the frequency response
of the photodetector is less than a maximum frequency of the data lasers and equal to or greater than the modulating
30 frequency.

12. The apparatus of claim 8 wherein the peak detector comprises:

an input that accepts an output of the photo detector;
a capacitance that accepts the output of the photodetector from the peak detector input and holds the

1 output of the peak detector; and
means for producing a slow discharge of the capacitance.

13. The apparatus of claim 12 wherein the means for producing
5 a slow discharge of the capacitance comprises:

a transistor, having a base collector and emitter,
wherein the base of the transistor provides a discharge path
for the capacitance; and

a constant current source coupled to the emitter circuit
10 of the transistor.

14. The apparatus of claim 2 wherein the plurality of high-
speed current drivers receive power from a first power supply,
and the remainder of the integrated circuit receives its power
15 from a second power supply thereby reducing the overall power
consumed.

15. The apparatus of claim 10 further comprising a modulator
that modulates the control laser with a signal having a lower
20 frequency than a maximum frequency of any of the data lasers.

16. The apparatus of claim 15 wherein the maximum frequency
response of the photo detector is lower than a maximum
frequency of any of the data lasers.

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17. An apparatus for driving lasers, the apparatus
comprising:

a laser current controller for providing a modulation
signal and a bias signal;

30 a plurality of high-speed current drivers that accept the
modulation signal and the bias signal and produce a plurality
of laser drive signals; and

a feedback circuit that detects laser light produced by a
laser driven by one of the high-speed current drivers to
produce a modulation feedback signal and a bias feedback
signal for provision to the laser current controller.

- 1 18. An apparatus as in claim 17 wherein the laser current controller and the plurality of high-speed current drivers are integrated on an integrated circuit.
- 5 19 The apparatus of claim 18 further comprising a laser array integrated on the integrated circuit.
20. The apparatus of claim 17 wherein the feedback circuit further comprises a photo detector having lower frequency
10 response than a maximum frequency of any of the data lasers.
21. An apparatus as in claim 17 further comprising a signal generator that generates a modulating signal that modulates the laser producing the laser light detected by the photo
15 detector, said modulation signal being of substantially lower frequency than a maximum frequency of any of the data lasers.
22. An apparatus as in 17 wherein the feedback circuit comprises:
20 a photodetector that accepts the laser light and produces a proportional voltage;
a peak detector that accepts an output of the photo detector;
a capacitance that holds the output of the peak detector;
25 and
means for producing a slow discharge of the capacitance.
23. An apparatus as in claim 22 wherein the means for producing a slow discharge of the capacitance comprises:
30 a transistor, wherein the base of the transistor provides a discharge path for the capacitance; and
a constant current source within the emitter circuit of the transistor.
24. The apparatus of claim 18 wherein the plurality of high-speed current drivers receive power from a first power supply,

1 and the remainder of the integrated circuit receives its power from a second power supply thereby reducing the overall power consumed.

5 25. An apparatus for driving lasers, the apparatus comprising:

a laser current controller for providing a modulation signal and a bias signal;

10 a plurality of high-speed current drivers that accept the modulation signal and the bias signal and produce a plurality of laser drive signals;

a disable input that disconnects power from a high-speed current driver when the high-speed current driver is not in use;

15 a feedback laser that is driven from one of the plurality of high-speed current drivers; and

a feedback circuit, including a photodetector that accepts light from the feedback laser and produces a modulation feedback signal and a bias feedback signal, said
20 photodetector having a cutoff frequency lower than the maximum frequency of the high-speed current drivers.

26. The apparatus as in claim 25 further comprising a signal generator that modulates the feedback laser with a signal
25 having a lower frequency than the maximum frequency of the high-speed current drivers.

27. An apparatus as in claim 25 wherein the feedback circuit further comprises:

30 a peak detector that accepts an output of the photodetector;

a capacitance that holds the output of the peak detector; and

means for producing a slow discharge of the capacitance.

- 1 28. An apparatus as in claim 27 wherein the means for
producing a slow discharge of the capacitance comprises:
a transistor having a collector, emitter and base,
wherein the base of the transistor provides a discharge path
5 for the capacitance; and
a constant current source within the emitter circuit of
the transistor.
- 10 29. The apparatus of claim 28 wherein the high-speed current
driver and the laser current controller are integrated on the
same integrated circuit.
- 15 30. The apparatus of claim 29 wherein the plurality of high-
speed current drivers receive power from a first power supply,
and the remainder of the integrated circuit receives its power
from a second power supply thereby reducing the overall power
consumed.
- 20 31. A method for controlling a laser the method comprising:
providing an integrated high-speed current driver in an
integrated circuit;
driving an array of lasers from the integrated high-speed
current driver;
accepting laser light from one of the array of lasers in
25 a photodetector;
determining a maximum and a minimum level of light
received from the laser that is providing light for the
photodetector;
using the maximum and the minimum level of light received
30 from the laser to produce a modulation feedback signal and a
bias feedback signal;
using the modulation feedback signal and the bias
feedback signal to produce a modulation and a bias signal; and
using the modulation signal and the bias signal to set
the modulation and bias in the integrated high-speed current
driver.

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32. A method as in claim 31 wherein accepting laser light from one of the array of lasers in a photodetector comprises accepting laser light from a laser being modulated at a
5 frequency less than the maximum frequency of the high-speed current driver.

33. A method as in claim 31 wherein accepting laser light from one of the array of lasers in a photocell comprises
10 accepting laser light from a laser being modulated at a frequency of approximately 100 MHZ.

34. A method as in claim 31 wherein determining a maximum and a minimum level of light received from the laser that is
15 providing light for the photocell comprises;

accepting a signal representative of the intensity of the laser light into a peak detector circuit; and

discharging the peak detector circuit by coupling a sampling capacitor, which holds peak detector voltage, to the
20 base of an transistor and controlling the current of the transistor using a constant current supply.

35. An apparatus for driving a laser the apparatus comprising:

25 a current sink;

a differential pair of PNP transistors, each transistor having a base, emitter and collector the bases being coupled together, and the emitters being coupled to a supply voltage Vcc,

30 a differential pair of NPN transistors, each transistor having a base, emitter and collector the emitters being joined at a junction with the current sink, the bases providing the input across which and input signal is developed, and

a load junction of the collector of one of the PNP transistors and one of the collectors of one of the NPN transistors that is coupled to a laser load.

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36. An apparatus as in claim 35 wherein the load junction is coupled to the base junction of the PNP transistors by a feedback resistor.

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37. An apparatus as in 36 wherein the feedback resistor is coupled between the load junction and the base of a PNP feedback transistor; and

10 the emitter of the PNP feedback transistor is coupled to the base junction of the PNP differential transistor pair.

38. An apparatus as in claim 35 wherein the load junction is further coupled to a first end of a series resistor-capacitor circuit and the second end of the series resistor-capacitor
15 circuit is coupled to ground.

39. An apparatus as in claim 35 wherein the load junction is further coupled to a first end of a series resistor-capacitor circuit and the second end of the series resistor-capacitor
20 circuit is coupled to a power supply.

40. An apparatus as in claim 35 further comprising an inductor disposed between the load junction and the load.

25 41. A laser driver for driving a laser, the laser driver comprising:

a first control circuit for receiving power from a power supply and for providing current to drive a first laser; and

30 a switch located between the power supply and the control circuit,

wherein the switch is used to control the current provided to the laser.

42. The laser driver for driving a laser of claim 41, the laser driver further comprising:

1 a second control circuit for receiving power from the power
supply and for providing current to drive a second laser,
wherein the second control circuit is coupled to the power
supply with no switch between the second control circuit and the
5 power supply.

43. The laser driver for driving a laser of claim 42 wherein the
switch deactivates the first control circuit upon assertion of
a power down select signal, while the second control circuit is
10 not affected by the power down select signal.

44. A laser driver for driving a laser comprising:
a first feedback loop for adjusting a modulation current
provided to the laser; and
15 a second feedback loop for adjusting a bias current
provided to the laser.

45. The laser driver for driving a laser of claim 44 wherein the
modulation current and the bias current are used to drive an
20 array of lasers.

46. The laser driver for driving a laser of claim 44 wherein the
modulation current is adjusted to control a peak-to-peak
amplitude of a laser output.
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47. The laser driver for driving a laser of claim 44 wherein the
bias current is adjusted to control an average optical power of
a laser output.

30 48. The laser driver for driving a laser of claim 44 further
comprising an array of laser drivers, each laser driver for
driving a corresponding laser, wherein the first feedback loop
and the second feedback loop are used to adjust the modulation
and bias currents for the array of laser drivers.

1 49. The laser driver for driving a laser of claim 44 wherein the first feedback loop includes a transimpedance amplifier (TIA) for converting a current generated by a feedback light into a feedback voltage used to adjust the modulation current.

5 50. The laser driver for driving a laser of claim 44 wherein the second feedback loop includes an amplifier for generating a feedback voltage used to adjust the bias current.

10 51. The laser driver for driving a laser of claim 48 wherein a particular laser corresponding to a particular laser driver is used to provide a feedback light to both the first and second feedback loops.

15 52. The laser driver for driving a laser of claim 48 wherein data transmitted using the laser has a pseudo random signal format or a format in which the data has a high statistical probability of having a sufficient number of consecutive "1's" so as to sufficiently charge a charge accumulation capacitor to enable detection of a value that is close to a peak value of a laser output.

20 53. The laser driver for driving a laser of claim 48 further comprising a control laser driver for driving a control laser, wherein the control laser is used to provide a feedback light to both the first and second feedback loops, and an oscillation frequency of a signal that drives the control laser driver is significantly lower than a frequency of a data signal provided to the array of laser drivers.

25 54. The laser driver for driving a laser of claim 52 wherein capacitance of the charge accumulation capacitor is adjusted to control a discharge time of the charge accumulation capacitor.

1 55. The laser driver for driving a laser of claim 52 wherein a
base leakage current of a transistor is used to discharge the
charge accumulation capacitor so as to lengthen a discharge time
of the charge accumulation capacitor.

5 56. A laser driver for driving a laser comprising:
first circuitry for receiving approximately 2.5V power to
perform various laser driver functions; and
second circuitry for receiving approximately 3.3V power to
10 perform laser output stage functions.

57. A laser driver for driving a longwave VCSEL comprising:
control circuitry; and
laser output circuitry,
15 wherein a voltage lower than a typical low voltage for
shortwave VCSEL is used to power the laser driver.

58. The laser driver for driving a longwave VCSEL of claim 57
wherein the voltage lower than the typical low voltage for
20 shortwave VCSEL is less than or equal to approximately 1.5V.

59. The laser driver for driving a longwave VCSEL of claim 18
wherein a direct coupling is used to provide power to the laser
driver so as to reduce power consumption associated with ac
25 coupling.

60. A laser driver for driving a laser comprising:
A PNP current mirror to supply current for driving the
laser,
30 wherein the PNP current mirror includes a feedback resistor
that can be adjusted to flatten a low frequency dip in an ac
magnitude response of a laser output.

61. An integrated circuit comprising:
means for setting a bias current and a modulation current
and for delivering each of said bias current and said modulation

- 1 current to each laser driver of an array of laser drivers, each laser driver driving a laser of a corresponding array of lasers;
means for accepting P_{avg} information regarding an average optical output power of said lasers of said array of lasers;
5 means for accepting $P_{peak-peak}$ information regarding peak-peak power amplitude of said optical output of said lasers of said array of lasers;
means for adjusting said bias current based upon said P_{avg} information; and
10 means for adjusting said modulation current based upon said $P_{peak-peak}$ information.

62. The integrated circuit as in claim 61, further comprising a photodetector and associated circuitry capable of developing
15 said P_{avg} information and said $P_{peak-peak}$ information.

63. The integrated circuit as in claim 61, wherein said lasers comprise VCSELs.

- 20 64. The integrated circuit as in claim 61, further comprising:
a further laser;
means for providing a pilot signal having a first frequency to said further laser; and
means for delivering a data signal to each laser of said
25 array of lasers, each data signal having a second frequency being greater than said first frequency,
wherein said P_{avg} information and $P_{peak-peak}$ information are obtained from light emitted from said further laser.

- 30 65. A method for driving a VCSEL comprising:
providing a VCSEL and a corresponding VCSEL driver;
providing a bias current and a modulation current to said VCSEL driver to effectuate said VCSEL emitting a light signal including a first average power level and a first peak-to-peak power amplitude;

1 providing a data signal having a first data rate to said VCSEL driver;

detecting a second average power level and a second peak-to-peak power amplitude of a light signal emitted from a further VCSEL responsive to a further data signal having a further data rate being less than said first data rate; and

adjusting each of said bias current and said modulation current to maintain said VCSEL emitting light at said first average power level and said first peak-to-peak power amplitude based on said detecting.

66. A method for driving a VCSEL, comprising:

(a) providing a VCSEL and a corresponding VCSEL driver;
(b) providing each of a bias current and a modulation current to said VCSEL driver;

(c) providing a data signal having a first data rate being greater than 2.0 GBPS to said VCSEL driver;

(d) detecting an average power and a peak-to-peak power amplitude of an optical signal emitted by said VCSEL using a photodetector operating at a data rate being less than said first data rate; and

(e) adjusting each of said bias current and said modulation current to urge said VCSEL to emit a light signal having a desired average power and a desired peak-to-peak power amplitude.

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